COST CONTAINMENT AND KSC SHUTTLE FACILITIES

OR

COST CONTAINMENT AND AEROSPACE CONSTRUCTION

BY

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INTRODUCTION

The purpose of this presentation is to show examples of Cost Containment of Aerospace Construction at Kennedy Space Center that were used in the four major levels of Project Development of the Space Shuttle Facilities . The Levels are: 1. Conceptual Criteria and Site Selection; 2. Design - of Construction and Ground Support Equipment; 3. Construction of Facilities and Ground Support Equipment (GSE); 4. Operation and Maintenance. These Cost Containment methods were so successful that the Space Shuttle is now operational with three (3) Orbiters - Columbia, Challenger, and Discovery, now scheduled for monthly launches and landings in 1985.

Space Shuttle Estimating - Cost Management Background

The concept of the Kennedy Space Center (KSC) Shuttle facilities was developed in late 60's and early 70's based on limited criteria, reuse of Apollo facilities, as much as possible and two simultaneous Shuttle-Orbiter flows, was conceptually costed by KSC's Design Engineering March-October 1970.

The conceptual construction cost estimate of facilities was $147,573,000, which included 10% contingencies and 7% S&A. This was further developed and escalated to $297,330,000 and included GSE equipment.

The construction of facilities was budgeted in the early 1970's at $150 M of 1970 dollars. The actual in-place cost through April 1980 was $225.3 M which is about 2% less than the original escalated budgeted amount. Quite a remarkable achievement. Some important scope changes that made this cost management more critical was the added Sound Suppression System and the redesign of the Rotary Service Structure for extra Air Force requirements after bidding LC-39 Pad A (during construction of the foundation).

A summary cost breakdown for the Cof F Shuttle	Millions
Orbiter Landing Facility	27.3
Orbiter Processing Facility	27.4
Launch Complex 39 Pad A	40.4
Launch Complex 39 Pad B	51.7
Mobile Launcher Platform #1	13.8

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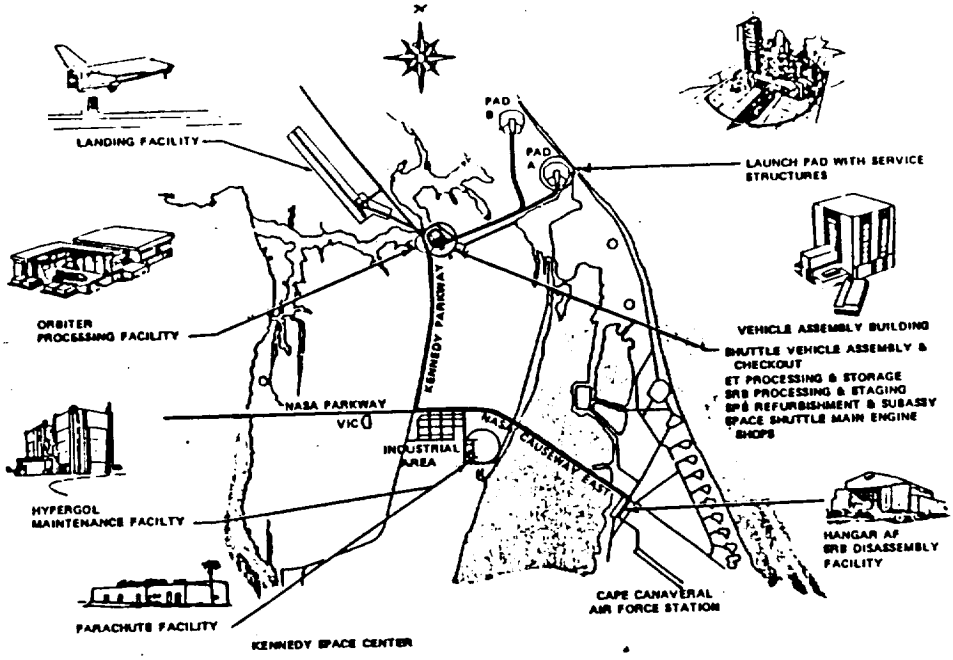
Mobile Launcher Platform #2	13.9
Vehicle Assembly Building	23.8
Launch Control Center	2.0
Solid Rocket Booster Disassembly (Hangar AF)	6.2
Parachute Facility	1.7
Hypergol Maintenance Facility	5.3
Launch Equipment Test Facility	2.0
Rehabilitation of Barge Channels	2.1
Construction Emergency Power Facility	2.2
Mods to Crawler Transporter Maintenance Facility	1.3
Shuttle/Carrier Aircraft Mating Facility	1.7
Miscellaneous Modifications	2.5
Subtotal Shuttle	225.3

The successful construction of the KSC Shuttle facilities under budget on schedule is a tribute to the remarkable KSC Design Engineering and construction management team. This is especially noteworthy for a research and development project. Many Research & Development (R&D) projects during the 70's were costing two times to three times budgeted costs due to the energy crisis; social, environmental and economical regulations; environmental requirements and concerns, and erratic (volatile) economy.

These, and many other problems, were solved by fast tracking, detail planning and scheduling, cost and design engineering solutions through an unusual efficient construction management program.

See Figure A, page 3, for KSC major Facilities Pictorial Baseline.
See Figure B, page 3, for the Space Shuttle Mission Profile.

Aerospace construction is similar to building, civil, petro-chemical process industry, construction in that it uses concrete,steel, form work and most conventional materials but it is different and more costly due to its higher



KSC Major Shuttle Facilities - Pictorial Baseline

FIGURE A

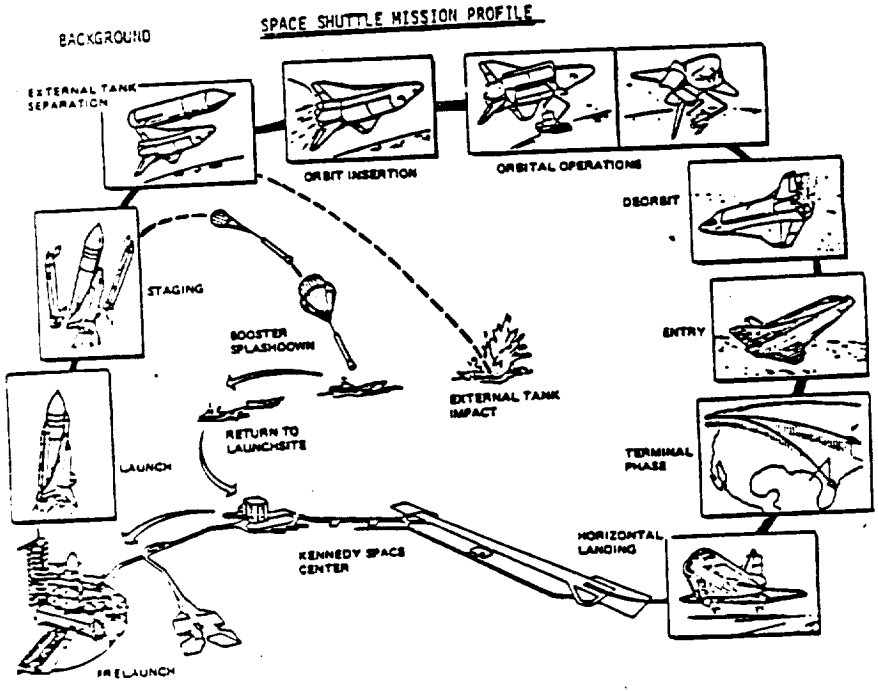


FIGURE B

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reliability requirements, tolerance, and safety requirements because of the hazardous operations, remote controlled fuels and gases and some exotic materials.

EXAMPLES OF COST CONTAINMENT AND KSC SPACE SHUTTLE FACILITIES

Level I Conceptual Criteria and Site Development

A. KSC was selected as the major launch and landing site after studying six locations throughout the United States of America (USA). They were White Sands Missile Range, Western Test Range, Edwards AFB, Wendover AFB, Ideal Location, and Kennedy Space Center (KSC). KSC was selected because it was the most cost effective for the following reasons:

1. Lower facility construction cost. Do to reuse of Apollo Launch Facilities. Example use of VAB, Launch Pads, and Crawleraway. This was proven by excellent Conceptual Cost Estimating and Cost /Engineering for all six locations. This has been documented in KSC Design Engineering Study dated October 1970.

2. Lower cost by using existing downrange tracking facilities.

3. Provides the safety of over water launches. (See Figure B)

4. Less environmental effect than other locations.

5. More payload boost with less fuel at this latitude or giving an extra 1000 pound payload per launch.

B. The location of new buildings and facilities was again for cost containment by locating the new Shuttle Landing Facility (SLF) near the Vehicle Assembly Building (VAB)/Crawleraway and Launch Pads. The Orbiter Processing Facility (OPF) was located on the Towaway between the SLF and the VAB, See Figure A - This was done to keep costs containeddue to the high cost of new roads, utilities, etc.

C. The criteria was developed by a team effort National Aeronautics and Space Administration (NASA) Civil Service/Private Industry/Support Contractors/ Architect Engineers/Construction/ Aerospace Contractors.

The conceptual criteria and site selection is providing a good choice as noted in Space Shuttle Estimating Cost Management Background, as under budget and on schedule and by fourteen successful launches and two landings at KSC.

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Level 2 Design of Construction and GSE

Examples of Cost Containment at this Level are:

1. The use of design to cost limits in Architect/Engineers (A&E) Contracts.

2. Cost Engineering throughout the design cycle in budget, Preliminary Engineering Report (PER) at the 30%, 60%, 90% and 100% design milestones, see SRB Comparison of Budgeted and Estimated Cost. See Figure C. paage 7.

3. The use of Consultants where needed.

4. The use of the Construction ManagementConcept for many major projects. Examples: Pad B, Mobile Launch Platform #3 (MLP).

5. The use of Detail Planning and Scheduling and Fast-tracking to save time and money. Example of Phased design are the runway in three phases, the Launch Pads and MLP's.

6. The use of Computer Aided Design/Drafting.

7. The special use of cost engineering by developing new estimating specification - (Construction and GSE) a KSC Cost Index, an Aerospace Price Book, A Summary of Abstract of Bids, and A Cost Engineering Format for Construction Management. With these tools the engineers were able to recognize cost/value. An example was the use of aluminum duct in the Orbiter Processing Facility (OPF) to provide clean air to high bay. The A&E had designed a stainless steel duct system which cost $250,000 extra. This helped keep the cost of the OPF within the budget. Millions of dollars of other saving have been documented in piping, cabling, and bridges and GSE.

8. The use of working models so engineers and others could understand and make it work - better - especially useful on Rotary Service Structure (RSS), GSE, Platforms.

Level 3 - Construction, Fabrication Assembly and Testing

Examples of Cost Containment are:

1. Coordinated Design Engineering (DE) /A&E/Construction Contractor/ Vendors/Fabrications and Government Furnished Equipment (GFE).

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2. The use of detail and overview planning and scheduling, Critical Path Method (CPM), Quality Control, and Safety Requirements.

3. Construction Inspection and Site Surveillance.

4. Pre-Bid and Pre-Work Conferences.

5. By using unit prices in bid to help eliminate contractor contingencies, example: Shuttle Landing Facility (SLF), (Excavation), Launch Complex (LC) 39 Pad B - Piling.

6. By using contract clauses such as joint occupancy, downtime, etc., in major contracts where needed. It allowed the government to Bid Change Orders - If necessary - Mobile Launch Platform (MLP) 2 and Pad A sound Suppression, etc.

7. Trying to limit design changes - Is it that necessary?

8. By reviewing the Government Estimate with the Low Bidder when a large difference. Show some contractor's their mistakes thus giving the government better and more complete construction with less claims.

9. By Phased Construction of Runway, Launch Pads, MLP's, Shuttle/Carrier Aircraft Mating Facility.

The effectiveness of KSC Cost Containment was again proved by construction completion on schedule and under budget.

Level 4 - Operations and Maintenance

In construction this may be referred to as Occupancy and Use Phase. Some examples of cost containment at this level are:

1. The continued use and reuse of existing facilities some to be used up to 325 times such as VAB, Crawler, and Crawlaway.and Launch Pads, etc.

2. The reuse of most parts of the Shuttle Fleet. Such as the Orbiters to be reused up to 100 times and the Solid Rocket Booster (SRB) Shells and casings to be used up to twenty-five times.

FIGURE C

COMPARISON OF BUDGETED AND ESTIMATED COSTS

SHEET _____ OF _____

DRAWING NUMBER 79K21364 SPECS. 79K21365 DWG. | SHEETS 860 154 | PCN 81302 | LOCATION KSC | PROJECT SOLID ROCKET BOOSTER ROTATION & PROCESSING FACILITY. R&P BLDG., SUPPORT BLDG., STORAGE/SURGE BLDGS.

WORK ORDER/CONTRACT PRC W.O. 4403 FOR SYS. SUMMARY ONLY | ARCHITECT/ENGINEER DANIEL, MANN, JOHNSON & MENDENHALL | ESTIMATOR G.L. FILES, DMJM PRC-1391 | CHECKER | CODE C-100 | SUBMITTED 5/27/82

ESTIMATED COSTS

BUDGETED LINE ITEMS	BUDGETED COSTS	1979 8-19-80 NOT SHOWN CODE PER	% DIF.	6-5-81 CODE B-30	% DIF.	7-8-81 CODE B-30 REV	% DIF.	8-13-81 CODE C-60	% DIF.	10-23-81 CODE C-90	% DIF.	12-16-81 CODE C-95	% DIF.	3-12-82 CODE C-100	% DIF.	OFFICIAL GOVT. EST. PROJ. CCE LOW BIDDER CODE	REMARKS
I SITEWORK		689,250	-17	573,700	+5	600,000	-5	569,600	+1	576,000	+14	(21) 656,500	0	656,500			
II BLDG. STRUCTURE																	
R/P BLDG.																	
ARCH/STR		4,504,550	-10	(1) 4,063,000	-4	(2) 3,895,000	+2	(3) 3,960,000	-1	(14) 3,909,170	-4	(21) 3,772,070	0	3,772,070			
MECHANICAL		120,600	+21	145,300	-27	(4) 106,050	+25	132,840	+12	148,412	+2	(16) 151,810	0	151,810			
ELECTRICAL		454,750	-18	375,000	-4	361,600	-9	329,800	+3	340,010	+24	(17) 421,900	0	421,900			
R/P TOTAL		5,079,900	-10	4,583,300	-5	4,362,650		4,422,640	-1	4,397,592	-1	4,345,780	0	4,345,780			
SUPPORT BLDG.																	
ARCH/STR		257,960	+13	291,500	-8	(5) 267,000	-16	224,800	-46	(13) 120,450	0	120,900	0	120,900			
MECHANICAL		54,480	+41	79,920	-22	59,670	+3	61,600	+5	64,670	+2	(16) 65,650	0	65,650			
ELECTRICAL		41,760	547	(6) 270,000	-84	42,200	+24	52,270	+15	60,070	0	60,070	0	60,070			
S.B. TOTAL		354,200	+80	638,420	-42	368,870	-8	338,670	-28	245,190	+1	246,620	0	246,620			
STORAGE/SURGE BLDGS.																	
ARCH/STR		1,195,900	+22	(7) 1,456,000	-8	(8) 1,335,660	+2	1,366,800	-10	(14) 1,225,380	-2	(16) 1,198,600	0	1,198,600			
ELECTRICAL		66,600	+36	90,800	+8	98,400	+10	108,000	-10	96,960	0	96,960	0	96,960			
S/S.B. TOTAL		1,262,500	+23	1,546,800	-7	1,434,060	+3	1,474,800	-10	1,322,340	-2	1,295,560	0	1,295,560			
III UTILITIES TOTAL		653,250	+4	682,000	+16	(9) 793,700	+24	980,900	-4	(10) 941,400	+22	(19) 1,145,600	0	1,145,600			
ELEC WITHOUT SPL. COND.		8,039,100	0	8,024,220	-6	7,559,280	+3	7,786,610	-4	7,482,522	+3	7,690,060	0	7,690,060			
ESCALATION/SPL. COND.		1,951,351	-19	1,588,780	-31	(11) 1,095,820	-3	1,066,590	-20	851,368	+3	(20) 875,140	-75	(23) 222,702			
SUB-TOTAL		9,990,451	-4	9,613,000	-10	8,655,100	+2	8,853,200	-6	8,333,890	+3	8,565,200	-8	7,912,762		7,247,000	
SUPER. & ADMINISTRATION		1,012,033	-5	961,100	-11	858,800	+3	885,300	-6	832,810	+3	856,600				724,700	
CONTINGENCIES		1,112,061	-5	1,054,900	-10	949,800	+2	973,700	-6	914,300	+3	941,900				797,170	
CCE		12,114,545	-4	11,629,000	-10	10,463,700	+2	10,712,200	-6	10,081,000	+3	10,363,700				8,768,870	
IV SPECIALIZED CONSTR.		735,400	+24	910,000	-4	870,000	-18	711,000	0	721,000	0	721,000		(NIC)		744,620	R/P PALLETS BID
TOTAL	10,200,000	12,849,945	-2	12,539,000	-10	11,333,700	+1	11,423,200	-5	10,802,000	-4	11,084,700				(22) 9,513,490	3-26-82 $744,620
PCT. DIFFERENCE, BUDGETED/ESTIMATED TOTALS		+26	+23		+11		+12		+1		0		-22				

NOTES BUDGET: $10,200,000 BLDGS., $2,200,000 TWO 200 TON BRIDGE CRANES. (1) BRIDGE CRANES NIC. (2) STEEL TONNAGE REDUCED. (3) STEEL PRICE INCREASED. (4) B-30 HAD REDUNDANT MARK UPS. (5) STEEL TONNAGE REDUCED. (6) 547% INCREASE DUE TO ADDED 2,000 KVA SUB-STATION. (7) SCOPE CHANGE TO TWO 8 SEGMENT STORAGE/SURGE BLDGS. (8) STEEL TONNAGE REDUCED. (9) SUB-STATION TRANSFERRED FROM BLDG. TO SITE. (10) CHANGE IN SCOPE AND SITE. (11) ESCALATION CHANGED FROM 12% TO 9.7% PER YEAR. (12) DETAILS ON PLATFORM WORK INDICATE MORE WORK THAN PREVIOUSLY ALLOWED. (13) CHANGED TO PRE-FAB BLDG. (14) REDUCED BLDG. SIZE. (15) CHANGED PLATFORM DECK FROM ALUMINUM TREAD PLATE TO GALV. STEEL. (16) LABOR RATE INCREASE. (17) ADDED SPL. SYSTEMS. (18) CHANGED ROOF INSULATION. (19) ADDED REQUIREMENT FOR BORING & JACKING. (20) SLIP IN SCHEDULE. (21) DESIGN DEVELOPMENT. (22) $9,513,490 PLUS $1,798,000 ((CRANE BID) = $11,311,490: -9% DELTA OF $12,400,000 TOTAL PROJECT BUDGET. (23) REDUCED BY 10-FED-1 AND -31.

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3. The special Research and Development (R&D) effort to develop efficient cost effective GSE such as Special Mechanical/Machinery and Platforms to speed operations, maintenance and check-out - Transporters, canisters, dollies, handling equipment, remote controlled electronic mechanical systems, swing arms, etc.

4. Re-bid and consolidation of Operation Support Contractors - Example: Shuttle Processing Contract (SPC). Combining many contractors to Lockheed, Base Operation Contract (BOC), EG&G, and any future Cargo Processing Contracts (CPC).

5. Providing mass purchasing for large use items such as a GN_2 Manufacturing Plant build by Big 3 at Gate 2, State Road 3.

6. Continuing effort to contain cost by studying other potential savings such as polygeneration to save rocket fuel and energy cost.

7. The use of full scale mock-ups to test and check-out Facilities and Operation. The "enterprise" Orbiter check-out of VAB and Launch Pad Rotary Service Structure.

The success of these cost containment methods has again been proven by the continued reduction of processing time from landing to launching.

Conclusion

The real proof of the success of The Cost Containment of the KSC Shuttle Facilities will the known at the successful completion of the Space Shuttle Era and its use in the Proposed Space Station Program scheduled for 1992-93. In the mean time these facilities are being used to successfully process, check-out, launch and recovery elements of the Space Transport System which assures the United States continued pre-eminence in Space Exploration and Development.

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BIOGRAPHY

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Biography: Mr. Joseph A. Brown is employed as a Lead Cost Engineer for the National Aeronautics & Space Administration's Design Engineering Directorate. He prepares and reviews government and contractor's construction and GSE cost estimates of over $3 billion for design, fabrication and construction. He has received AACE's admission to grade of Fellow and the prestegious astronauts "Silver Snoopy" for professional excellence and his contributions to the success of our manned space efforts. He has written an Estimating Workbook and is writing "Estimation of Construction Costs and Cost Engineering." He has conducted Construction Cost Engineering Seminars from Miami to Montreal, Canada.